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ABSTRACT

The phrase "information on demand" is often used to describe situations in which digital electronic information can be delivered to particular points of need at times and in ways that are determined by the specific requirements of individual consumers or client groups. The advent of "mobile" computing equipment now makes the realization of this technique a practical reality. In order to discuss this approach to information provision, this paper classifies digital information archives into four basic types: global, local, isolated and mobile. The characteristics and properties of these different types of information are described and the relationships between them are then discussed. The taxonomy that is introduced is used as a basis for the presentation of a case study which illustrates some of the ways in which this type of equipment can be used to access, update and process remote online information in a totally interactive fashion. (Contains 25 references.) (Author)

Towards real information on demand

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Abstract: *The phrase 'information on demand' is often used to describe situations in which digital electronic information can be delivered to particular points of need at times and in ways that are determined by the specific requirements of individual consumers or client groups. The advent of 'mobile' computing equipment now makes the realisation of this technique a practical reality. In order to discuss this approach to information provision, this paper classifies digital information archives into four basic types: global, local, isolated and mobile. The characteristics and properties of these different types of information are described and the relationships between them are then discussed. The taxonomy that is introduced is used as a basis for the presentation of a case study which illustrates some of the ways in which this type of equipment can be used to access, update and process remote online information in a totally interactive fashion.*

Keywords: decision support, digital data archives, flexible access to information, information on demand, mobile computing, notebook computers, online information, personal digital assistants, problem-solving

1. Introduction

As a consequence of the various evolutionary changes that have taken place, the human species has risen to a position of uniqueness and prominence within the hierarchy of biological systems. The important developmental changes that have occurred during its evolution have resulted in the creation of a sophisticated psychocognitive system of control. Because of the complex nature of this control system, virtually all cognate human activity is governed by innate goal seeking behaviour. For example, the need to work, eat, communicate, learn and relax are all 'driven' by inherent goals that are derived from our sophisticated physical and cognitive make up.

Naturally, the realisation of any particular goal (within any given situational context) will usually involve the successful solution of an intricate pattern of problem-solving activities. The exact nature of the problems to be solved in any given situation will depend critically upon a number of generic control factors. Some of the more important of these are: the required outcomes; the quality of the solution necessary; resource issues (for example, finance, person-power, equipment and information availability); time scales; the problem setting; and so on. Fundamental to the appropriate use of resources to solve a problem is the associated decision-making activity that takes place. Ideally, this should lead to a solution that falls within the 'region of acceptability' for the problem being solved — bearing in mind the constraints imposed by the available resources, the time scales involved and the assumptions that are made ('the givens') at the onset of problem-solving activity.

Obviously, successful (and optimal) problem-solving depends critically on the quality of the decision-making that is used to pick out the most suitable pathway through a problem space. That is, the path from the initial state to the final state of problem-solving. Three different routes through a simplified problem space are illustrated schematically in Figure 1.

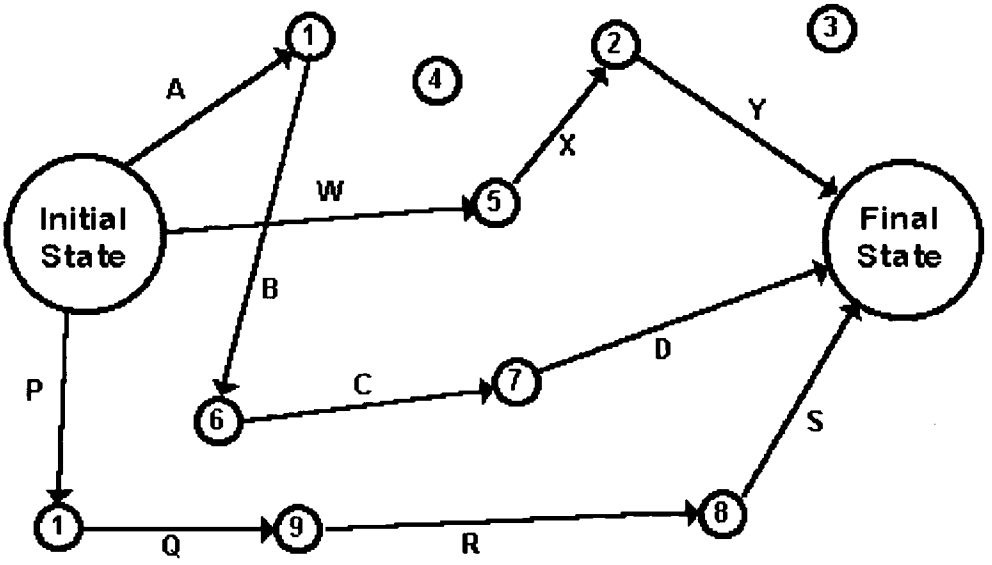
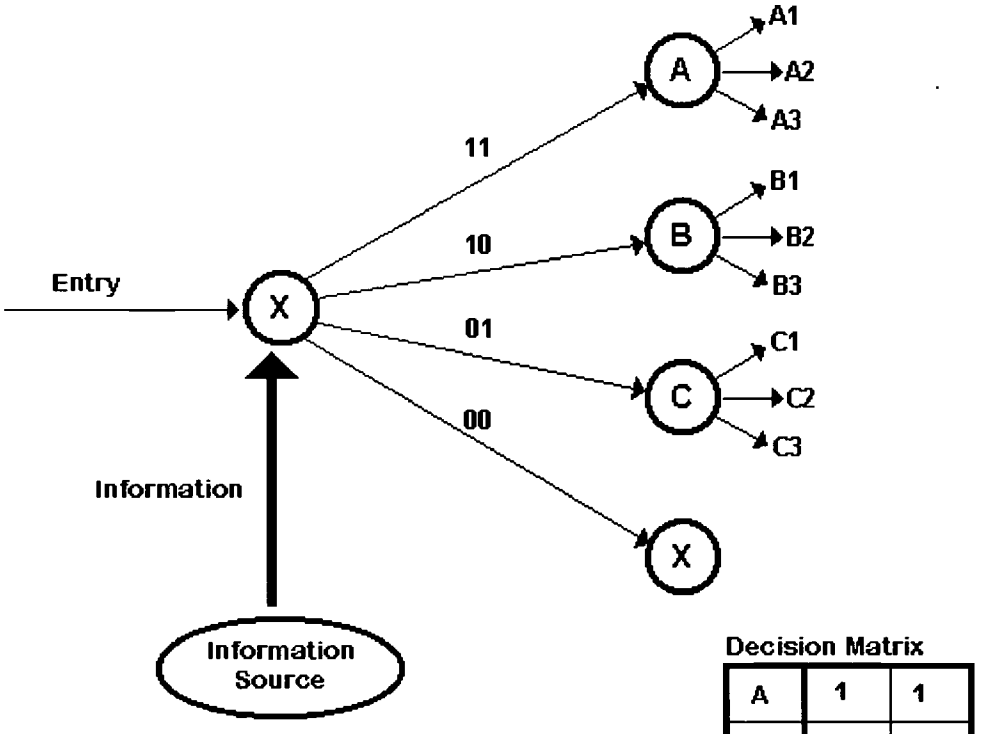


Figure 1: A problem-solving graph.



Decision Matrix

A	1	1
B	1	0
C	0	1
X	0	0

Figure 2: A decision tree and decision matrix.

Each of the pathways shown in Figure 1 differs from the others as a consequence of the different problem states that are visited during the transition from start to finish. These pathways (and hence, the particular states that are visited) will be determined by the decisions that are made during problem-solving. Naturally, the actual results of decision-making are extremely dependent upon the nature and the quality of the information that is available at the points (in Figure 1) at which decisions have to be made. Because of its importance in problem-solving, information has often been called the 'fuel' of decision-making.

The importance of information in decision-making is reflected in Figure 2 which shows a typical 'decision tree' corresponding to the choices of action that can be taken at a typical node during the course of solving a particular problem. Normally, each of the problem states within a given problem space like that shown in Figure 1 will correspond to a node in a graph similar to that depicted in Figure 2.

As was mentioned above, the pathway through a problem space will depend upon the quality and amount of information that is available to the decision makers who are responsible for steering problem-solving activity. Unfortunately, today there is so much information available in the world that no one individual can ever hope to acquire, access, process and use all of it. This plethora of knowledge that is now available has arisen for two basic reasons. First, the never-ending progress that is being made within all areas of human endeavour and its relationships to the natural evolution of the societies in which people live; and second, the breakdown and/or penetration of the international boundaries that exist between nations — thereby making the information available in any one country available in many others. Three important implications of having such vast amounts of information to cope with are:

(1) we must aim to make it available in electronic form in 'machine independent' ways (Ref 7);

(2) more effective, automated mechanisms for processing it must be made available;

(3) easy to use, location independent tools and techniques for accessing this electronic information must be provided.

It is this latter issue which is addressed in this paper. Particular attention is given to the provision of facilities to support 'information on demand': that is, making information available to those who need it when they need it, wherever they happen to be.

2. Types of information

From a problem-solving perspective, the breakdown of the national and international barriers and boundaries referred to above has many important consequences. Undoubtedly, two of the most pressing of these are (1) the growing global mobility of people (such as sales and marketing personnel and technical consultants) and the equipment (or support tools) to which they must have access in order to perform their jobs effectively; and (2) the need to develop appropriate information support services (both software- and hardware-based) that are location independent. Obviously, as individuals move from one location to another the information that each has available will vary considerably. The ease with which this information can be accessed will depend upon the format that it is in, the geographical location of the individual concerned and the types of equipment that are needed for accessing the available information.

In order to provide a basis for the discussion that is presented in the following sections of the paper it is necessary to classify information into four generic types which are referred to by the names: global, isolated, local and mobile. The relationship between these is illustrated schematically in Figure 3. This diagram is intended to reflect how the information available to a given decision maker varies as he or she moves from one particular geographical location (or work setting) to another { L_1, L_2, ... L_i }. Thus, at any given instant in time (t_i) a specified user who is located at a location (L_i) will have available particular measures of global information (g_i), mobile information (m_i) and local information (l_i). In addition, it is likely that at the instant in time being considered (t_i) a substantial volume of potentially useful information will be unavailable (u_i). This is referred to as 'isolated information' in Figure 3.

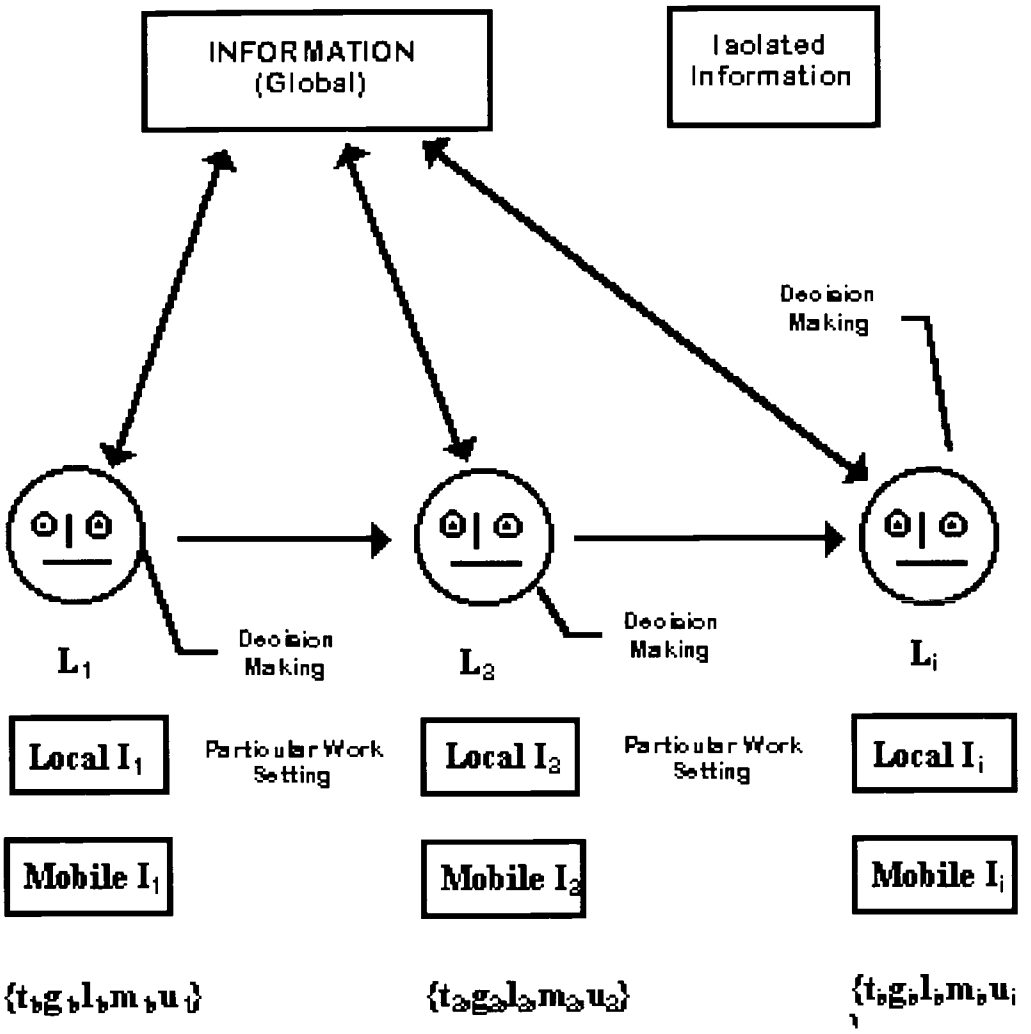


Figure 3: Relationship between local, global, mobile and isolated information.

Global information is information which is easily and widely accessible on a world-wide basis through electronic communication systems. These may be private or public networks and/or broadcasting systems of various sorts. Typical examples of global information are files of material that can be obtained from the Internet (using software such as FTP, for example) or downloaded from the World Wide Web. Obviously, global information may be either private (and possibly encrypted for use only within a closed user group) or publicly available for general consumption.

As its name suggests, isolated information is information that cannot be accessed directly from a particular work setting. Such information can arise from three basic types of situation: (1) information that cannot be accessed because it is not in electronic form; (2) information that is in electronic form but cannot be accessed because of connectivity problems (these my be transient, temporary or permanent); and (3) cases in which information is available online but cannot be accessed because of restricted access rights (that may be imposed for financial, political, security or ethical reasons). Sometimes it may be possible to access certain types of isolated information using special techniques such as 'fax back', or by requesting a 'media mount' operation to be performed by personnel located 'back at base'.

Local information refers to material that is available to a decision maker at the location where he/she happens to be working. For example, this might be a public or private library, or a workstation in a client's office. In this latter case, the computer equipment might provide access to an associated digital electronic library in the form of a collection of one or more CD-ROM discs, or an in-house 'intranet' facility (Refs 6, 12). This type of information is 'fixed' at the location where particular types of job-related decisions have to be made.

Mobile information corresponds to material which physically moves about with a decision maker as he or she travels around from one location to another. It might exist as material that is embedded within the internal storage facilities provided by a portable notebook computer or a palmtop computing facility. Alternatively, it might consist of data that is contained on floppy disks, portable hard disks, solid state disks or CD-ROM discs that are carried around with the computer system. Obviously, certain types of information that might normally be regarded as isolated (Figure 3) could be converted into mobile information by copying it across to a portable medium —

provided it exists in a digital format. The particular subset to be cross-loaded would obviously depend upon the problems to be solved at the locations that are to be visited.

One of the major objectives underlying the philosophy of information on demand is that we should consider ways of (1) minimising the amount of unavailable/isolated information and (2) maximising the volume of globally available information — bearing in mind the limitations and/or possibilities offered by local and mobile material. Some of the mechanisms by which this may be achieved are discussed in the following section.

3. Using portable computing equipment

As was discussed in the previous section, there is a growing demand for the provision of tools, techniques and facilities to make available information on demand in order to support decision-making and problem-solving processes that are not tied to a particular geographical location. The basic types of resource needed to realise this approach to information provision are illustrated schematically in Figure 4.

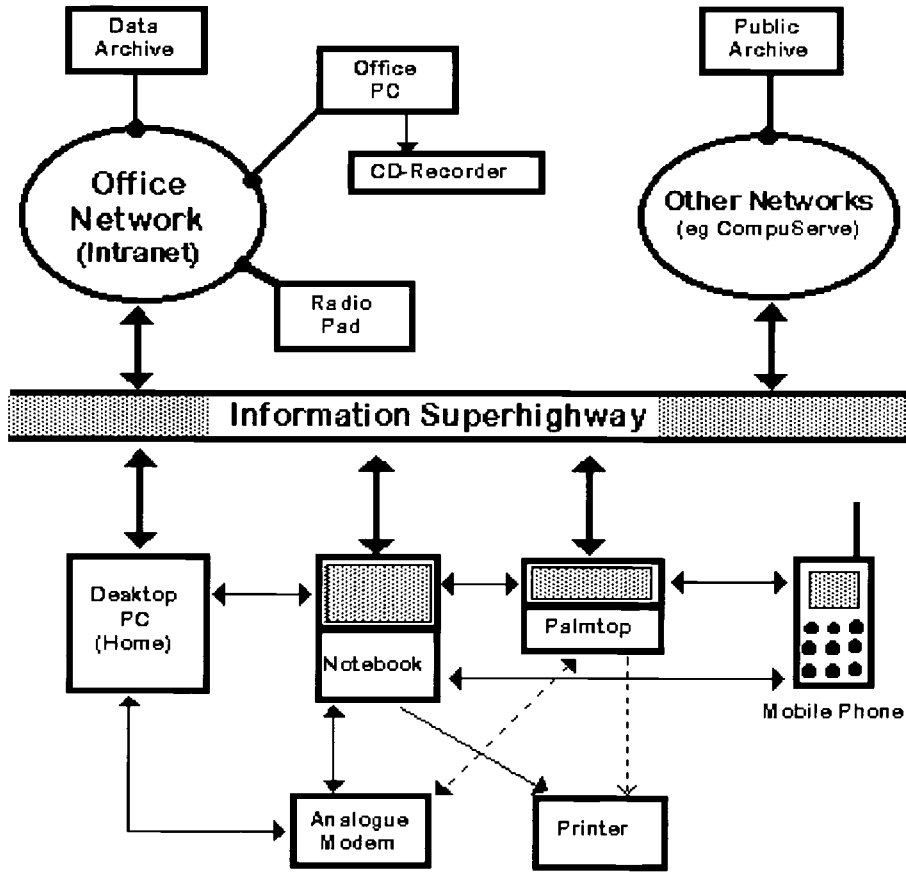


Figure 4: Technology to support information on demand.

In this diagram the important 'integrating' feature is the communication pipe that has been labelled 'information superhighway'. Within this paper this latter term is used in a generic way to refer to all the logical and physical communications infrastructure that is necessary to enable the various computing resources shown in the diagram to be interconnected, in order to facilitate remote information exchange in a global way.

The computing equipment that is illustrated within Figure 4 falls into two basic categories: (1) that which is located at fixed locations (such as the data archives and the office/home-based personal desktop computers); and (2) that which is portable and can be used at different geographical locations — depending upon the types of task to be executed and the nature of the problems that have to be solved. The portable computing equipment includes devices such as notebook and palmtop computers (and their associated peripherals), and digital hand-held portable telephone equipment. The important features of each of these types of resource and the ways in which they can be interconnected to facilitate information on demand are briefly discussed in the remaining parts of this section.

3.1. Notebook computers

Undoubtedly, one of the most popular types of portable equipment is the notebook computer. These come in a variety of different types but their underlying architecture and facilities are usually very similar (Ref 1). Their main features include an A4-size QWERTY keyboard, a high resolution LCD colour panel, a pointing device (mouse or tracker-ball), a large capacity hard disk (usually exchangeable), a CD-ROM drive (either built-in or external), embedded facilities for sound recording and reproduction, a floppy disk unit and a series of interface ports to enable connections to external devices to be made. The external ports usually include a serial communications port, a parallel printer port, a connection for an external CRT monitor and a PCMCIA facility.

PCMCIA is an acronym for Personal Computer Memory Card International Association (Ref 13); cards meeting this specification (Types I, II or III) have become an extremely popular way of expanding the facilities available on a notebook PC. For example, a typical PCMCIA port will allow a notebook to accommodate additional hard disks (such as the Callunacard), memory cards, serial ports (RS-232), fax/modem and data cards for connecting to analogue and digital (cellular) telephone facilities, SCSI devices (SCSI is an acronym for Small Computer Systems Interface) and various types of network card for attaching directly to local area networks (such as Ethernet, Token-Ring, and so on). A useful introduction to the PCMCIA standard and a summary of the different types of product available has recently been published by DIP Systems (Ref 5). The importance of the PCMCIA standard is reflected by the growing amount of online information relating to it — a recent Internet search revealed the presence of 9117 documents indexed on the word 'pcmcia'.

One of the attractive features of the PCMCIA equipment is the ease with which it allows the transfer of information from a desktop PC onto a portable hard disk, which can subsequently be plugged into a notebook computer. Mobile information (see Figure 3) can thus be carried on one or more PCMCIA ATA compatible hard disks. If more substantial volumes of information are to be transported then it is possible to make use of recordable CD ('gold') discs, using equipment that is attached to one of the resident desktop PCs. Also, as is discussed below, by using appropriate PCMCIA data and modem cards, it is possible to connect a notebook computer up to a digital mobile telephone or a conventional telephone network, thereby facilitating access to global information at various remote host sites.

3.2. Palmtop computers

Over the last few years there has been a tremendous growth in the popularity of hand-held computing devices. There has also been a substantial increase in the range of equipment that is available, varying in complexity from simple digital timers through dictionaries, language pronunciation aids and spell-checkers to personal organisers and fully fledged computing systems. Amongst the earliest of the 'more sophisticated' palmtop computers are included the Apple Newton Messagepad, the Amstrad PenPad PDA 600 and Acorn's Pocket Computer (Versions I and II). Systems like the Newton and the PenPad use a stylus to facilitate hand-written input of commands and data whereas the Pocket Computer uses a QWERTY keypad. Since the early introduction of these 'personal digital assistants' (or PDAs) there have been many rapid developments, and there is now a considerable range of equipment to choose from. Some of the latest examples of PDAs have recently been reviewed and compared by Rockman (Ref 12).

Palmtop systems are usually much smaller than notebook computers. Some typical dimensions (in mm) of a palmtop are 166 x 86 x 22 — compared with the corresponding measurements for a notebook which are 280 x 218 x 50. PDAs are also much lighter — typically, 275 gm compared with 2950 gm (a factor of ten less!). The essential hardware features of a PDA include a 'miniature' monochrome LCD display panel measuring about 134 mm (diagonal) and an augmented QWERTY keyboard that usually contains a range of extra keys for activating special functions and/or applications (such as a word-processor, spreadsheet, database, organiser, almanac, sound recorder, fax facility, file manager, calculator, 'comms' package, and so on). The screen and keypad are usually organised spatially in a 'clamshell' like arrangement — very similar to a notebook PC but on a much smaller scale.

As well as its internal memory, a palmtop PC will usually have one or more built-in data card slots and/or disk drives to facilitate the input and output of information using exchangeable solid state disks (both dynamic RAM and flash disks can usually be obtained). The capacity of add-on storage devices varies considerably depending upon the type of peripheral and the particular palmtop computer involved.

As is the case with notebook PCs, most palmtop systems also have some form of interface port. These can

be used to connect the computer up to other computers (see Figure 4) or to devices such as a printer or a modem. Just like notebook PCs, one of the commonest types of interface port is that based on the PCMCIA standard — however, a number of manufacturers employ their own proprietary standards for interface ports.

3.3. Making connections

As can be seen from Figure 4, there are various ways in which the mobile computing elements described above can be interconnected. The two major types of interconnection are those which enable (1) the exchange of local information (between a palmtop, a notebook and, possibly, a desktop system); and (2) the remote connection of a notebook and/or a palmtop PC to remote computers and data archives. These connections can be of either a permanent or a temporary nature. As far as the mobile equipment is concerned, virtually all of the connections will be of a temporary nature.

The exchange of local information can usually be achieved through the use of appropriate serial communication links and suitable client/server software that is installed on the two machines that are to be involved in data transfer. For making remote connections a suitable modem, data card or radio-pad is needed. Undoubtedly, the two most popular ways of making these remote connections employ either analogue (via a modem) or digital cellular networks (via a data card) — although in some cases radio data networks can be used (such as Paknet). Each approach has its advantages and disadvantages in terms of accessibility, cost and the information transfer services that are available. Some of these issues will be discussed in more detail in the case study that is presented later in the paper. Obviously, in order to access global information remotely using mobile equipment some form of server has to be set up 'back at base'. Some ways of doing this are briefly discussed in the following section.

3.4. Setting up information servers

One of the easiest ways of creating a 'base station' server is to use a desktop PC and a modem that is set up in 'call answer' mode. If a conventional public telephone line is then used to dial the modem, remote callers can gain access to information that is held on the server — just like a password protected bulletin-board system. Alternatively, if some sort of Internet connection (or similar network facility) is available then it is possible to use programs like FTP and telnet to gain access to and retrieve global information that is resident on a remote host.

Another important type of server facility for providing access to global information can be built using the World Wide Web (WWW) system. This can be used as a foundation for building quite sophisticated information structures which users can access remotely. There are three fairly simple approaches to mounting information on a Web server, depending upon the amount of information to be made available and the kinds of computing equipment available. The simplest approach is to build a series of pages and mount them on an office (or institutional) server that is located 'back at base': these pages can then be accessed directly with a suitable browser using an appropriate URL address. Alternatively, it may be possible to rent space on someone else's WWW server: this is a useful approach when relatively small volumes of information are involved and the costs of renting are attractive. The other approach is to set up a personal server running on a totally independent machine using software such as Spinnaker's Web Server (Ref 16). Obviously, each of these approaches has its attractions and limitations. In the case study described in the following section each of the three approaches has been used to provide access to information in a global way.

4. A case study — the Psion 3a

For many years I have been an avid user of notebook computers for accessing information while away from my home or office base. However, there are a number of ergonomic and technical limitations associated with using this type of equipment and so I recently explored the possibility of using a palmtop computer to overcome these. The main limitations of notebook computers as mobile resources are: (1) they tend to be bulky and quite heavy to carry (usually requiring some sort of shoulder-bag for transportation; (2) they have a sizeable 'footprint' and require a considerable amount of desktop working area for comfortable use; (3) they require quite a substantial amount of power and so there is only a limited working period available when using batteries; and (4) depending upon the initialisation routines that are invoked on power-up, there can be a substantial delay in getting at required information. Palmtop computers usually do not suffer from any of these limitations. Indeed, one of the attractive features of the Psion 3a (see below) is that it is possible to get access to its associated mobile information using just three key-presses (provided the system is not password protected). These involve: (1) switching on; (2) selecting the required application (say, a database or a spreadsheet); and (3) activating the application. All together, these operations take less than 10 seconds!

In the case study that is presented in the remainder of this section, the mobile computing equipment that has been used is based on the following three items: (1) a DECpc 425SLC/e Premium notebook PC with a PCMCIA port; (2) a Psion 3a palmtop computer with a full range of accessories (Ref 9); and (3) a Nokia 2110i mobile telephone with an accompanying PCMCIA compatible cellular data card (Ref 8). The case study provides an outline description of how this equipment can be used to provide an approach to providing real information on demand.

The Psion 3a is available in a range of different internal memory sizes from 256 Kbytes through to 2 Mbytes. The models with larger memory capacities usually have extra built-in software provided (such as a spell-checker

and a thesaurus). The computer has two peripheral ports for the insertion of solid state disks (SSDs); these vary in capacity from 128 Kbytes up to 4 Mbytes. The disks can be of two basic types: flash and RAM. Information held on RAM can be updated dynamically but that on flash disks cannot (other than by copying a new version of a file to its host disk). The system is powered by two AA batteries (typically, these provide up to 60 hours of use) and/or by a mains adapter. There is a single multi-purpose 'communications' port available which enables various types of system connectivity to be achieved (as is illustrated schematically in Figure 4).

The essential connectivity for the realisation of information on demand can be achieved using four basic types of inter-connecting cable. The simplest of these allows a Psion to be connected directly to a printer to facilitate the output of hardcopy. The second type of cable (the '3Link') is a serial RS-232 link which enables the palmtop to be linked to another computer (either a desktop or a notebook). This allows files of local information to be transferred between a Psion and other computers (at speeds up to 19 200 baud); it is also useful for backup purposes, enabling all the Psion's memory stores (both internal and SSDs) to be backed up onto a notebook or desktop computer. Two useful packages for this purpose are *RCOM*(for Microsoft DOS users) and *PsiWin* — the latter is able to perform automatic file conversion as they are moved/copied from a Psion to a computer running Microsoft's Windows (and vice versa).

From the perspective of accessing global information and communicating electronically with other colleagues, two of the most useful add-on cables are the *3Fax* fax/modem accessory (Ref 10) and the serial link that can be used to connect a Psion up to a Nokia 2110 digital mobile phone (Ref 11). The utility of each of these, from the perspective of providing information on demand, is briefly discussed below.

Global information can easily and rapidly be accessed using a Psion since, as well as facilitating the transmission of faxes, the analogue 3Fax modem allows the palmtop to be used as a mobile remote terminal from any location within the UK that makes available a standard British Telecom phone socket. In order to do this when travelling abroad, an appropriate set of modem adapter plugs usually has to be used to connect the Psion up to any particular national telephone network (Ref 15). Of course, to enable a Psion to act as a mobile terminal it is also necessary to install a suitable software communications package, such as the VT100 emulator from Widget Software (Ref 18). This allows remote computers to be accessed in the same way that a conventional terminal can be used: files can be uploaded and downloaded; e-mail can be sent and received via a remote host; and it is possible to access the Internet and World Wide Web (using the Lynx character-based browser). In situations where a telephone socket (or an ordinary phone) is not available, the Nokia 2110 mobile phone and a notebook computer can be used to download/upload files that, in turn, can be ported to/from a Psion via its serial link. Unfortunately, there is no terminal software presently available to enable a Psion to be used as a portable remote terminal using a mobile phone and a cellular data network. However, there is a simple 'telenote' facility that enables the Psion to send and receive short text messages via a mobile phone.

The 'telenote' facility is one of a number of SMS (Short Message Service) facilities that digital cellular networks now make available (Refs 11, 17). Telenotes, which may be up to 160 characters in length, can also be sent from an ordinary desktop or notebook computer using dial-up facilities (through an analogue modem). They may be sent to an individual or a nominated group of people, who can receive them on suitable digital mobile phones. If any particular targeted telephone is not online when a message is sent, it can be buffered and relayed onwards to the phone when it eventually comes online. Facilities of this sort are very useful for passing out 'snippits' of important information dynamically to decision makers and delivering urgent messages to colleagues.

Using the types of equipment described in this case study it is possible to implement a variety of physical mechanisms to facilitate the realisation of 'information on demand'. Unfortunately, having access to vast volumes of electronic information brings with it the problems of understanding its structure and knowing how to navigate through it in order to locate particular items of interest. In order to overcome these problems we have been using a metaphorical framework based upon the use of book, bookshelf and library metaphors. The ways in which these metaphors have been implemented are described in more detail elsewhere (Refs 2, 6, 14). Another important direction that our research is currently exploring involves the implementation of a 'virtual office' environment in which desktop, filing cabinet, telephone, fax and mail metaphors are integrated into a uniform and consistent metaphorical framework for the execution of office procedures (Ref 3). Obviously, such an office does not exist as 'bricks and mortar'; it only exists electronically within the shared cyberspace environments that can be made available through the use of distributed and dynamically re-configurable computer networks.

5. Conclusion

Mobile computing technologies of the type described in this paper have paved the way for the true realisation of information on demand: that is, the availability of sought-after information as, when and where it is needed. Although there are still some problems to be overcome because developments in this area are so rapid, the barriers that these pose will soon disappear (Ref 4). Obviously, this new technology brings with it important new opportunities for the realisation of many novel approaches to the realisation of online information. These can embed both well-established and forward-looking metaphorical frameworks that are able to make available new types of online environment which can provide better methods for organising information, and give easier access to it. Such frameworks will naturally place great (often unanticipated) demands on system designers. Furthermore, because mobile computing (and information on demand techniques) can be used to solve such a wide variety of problems, it is imperative that a dynamic and flexible system architecture can be developed and maintained. This is easily achieved through 'hot swapping' of peripherals on an 'on-demand'

basis in order to achieve required system functionality as and when it is needed. Naturally, ongoing developments in the field of PCMCIA interfaces can be used to meet the requirements outlined above by allowing users to mix and swap the various devices that are attached to their mobile computing equipment.

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